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BLACKLEG: ITS NATURE, CAUSE, AND PREVENTION.

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HISTORICAL REVIEW.

Although it was not until the last quarter of the past century that blackleg, or symptomatic anthrax, was definitely recognized as a distinct disease caused by a specific micro-organism, still there can be little doubt that it had existed for many centuries, and that a large number of the epizootics among cattle which are referred to by early historians and clinical observers as anthrax were really blackleg and not anthrax. This supposition is based on the fact that their description of the symptoms and post-mortem appearances in many cases corresponds more exactly with our present knowledge of blackleg than it does with anthrax.

In 1850 Rayer and Davaine discovered the anthrax bacillus in the blood of sheep which had died from anthrax; but, although a number of scientists verified this discovery, they did not recognize the bacillus as the cause of the disease, but considered its presence in the tissues and blood of affected animals as the result of the disease. Not until 1877 did Pasteur succeed in demonstrating that the bacillus was the one essential for the appearance of the disease; and in 1879 it was proved by Arloing, Cornevin, and Thomas that symptomatic anthrax, or blackleg, is caused by an entirely different organism, and consequently is a distinct disease. The following year the same authors published a description of the blackleg bacillus and demonstrated that the disease could be produced in susceptible animals by inoculation, and that immunity might be produced by introducing the bacillus into the circulation of such animals under certain favorable circumstances. This discovery was the beginning of a series of experiments which finally led to the introduction of preventive vaccination by hypodermic injections of blackleg virus which had been attenuated by means of heat.

GEOGRAPHICAL DISTRIBUTION.

There are but few countries in the world where blackleg does not prevail to some extent. The ravages of this disease are not confined to certain zones or altitudes, but occur as frequently in the extreme north as in the tropical regions, and as often on the highest mountain pastures as in the lowlands. It is therefore evident that the contagion of blackleg possesses an unrivaled power of resistance to the destructive influences of varying climatic conditions. In Europe it occurs as far north in Norway as cattle are kept, and it is doubtful whether a disease which often causes great loss among the reindeer herds in Lapland, northern Russia, and Siberia is not identical with blackleg. Furthermore, in Denmark, Germany, France, Spain, Italy, Austria-Hungary, the Netherlands, and England the disease is known and dreaded by cattle owners. On the summer pastures on the Alps in Switzerland, where for five months of the year the ground is covered with snow and ice, the disease appears regularly every summer when the cattle are brought from the lowlands, and sometimes carries off as high as 25 per cent of the young stock.

In France blackleg is regarded as the most destructive disease among the cattle, and it is especially the dairy districts and the mountain pastures which suffer the greatest losses. In the latter places the disease is called "mal de montagne," or mountain disease, but statistics show an equally great mortality among the cattle on the rich meadows and pastures along the great rivers. In the Bavarian Alps, in Tyrol and Vorarlberg, the disease is very severe on the young stock.

In Denmark the disease is well known, and has for more than a century been distinguished by laymen from other anthracoid diseases under the name of "raslesyge," which means rattle disease. In 1821 Viborg described the disease as occurring regularly in certain districts where it still appears up to the present time.

In Africa blackleg occurs both in the northern and southern colonies, especially in the French possessions in Algeria, where it frequently decimates the herds of young stock. Also in the southern British provinces, especially Natal, it has been reported to be very prevalent. The same seems to be the case with the English colonies in Asia, although no definite statistics to that effect can be obtained. In South America the disease prevails quite extensively throughout Argentina. Cattle in Cuba and Australia also suffer.

BLACKLEG IN THE UNITED STATES.

Up to the time when the Bureau of Animal Industry undertook to investigate the prevalence of blackleg in the United States it was merely known that it occurred in certain districts in this country. From the reports received during the investigation it became appar-

ent that the loss from blackleg in certain portions of several States exceeded that from all other causes combined. The States which principally suffer are Texas, New Mexico, Oklahoma, Kansas, Nebraska, Colorado, North Dakota, and South Dakota; but quite a number of other Western States are badly infected.

In the East a number of outbreaks have been reported from Virginia, West Virginia, and Pennsylvania, and scattering outbreaks have occurred in Vermont, New York, Ohio, Kentucky, Tennessee, and North Carolina. In the Central States outbreaks have been reported from Michigan, Indiana, Illinois, Wisconsin, Minnesota, Iowa, and Missouri; but it is principally the cattle-raising and cattle-feeding regions, which are bounded on the north and east by the Missouri and Mississippi Rivers and on the west by the Rocky Mountains, which suffer the most. In the extreme West the disease seems to prevail to a considerable extent in the States of Washington, Montana, Oregon, Idaho, Utah, California, and Arizona.

With the exception of the southern Atlantic and the eastern Gulf States there are but few districts in the United States where the disease has not been observed.

CONDITIONS INFLUENCING GENERAL OR INDIVIDUAL SUSCEPTIBILITY.

AGE OF CATTLE MOST FREQUENTLY AFFECTED.

Every stock owner who lives in a district where blackleg occurs knows that it is the young animals, especially those between the ages of 6 and 18 months, which are most liable to become affected. From a number of blackleg districts it has, however, been reported that the calves frequently begin to die at the age of 4 to 5 months, and cases of blackleg in even younger animals can not be considered exceedingly rare, although not numerous enough to be of any importance in the contemplation of preventive measures.

The increase in number of cases with the increase in age is very characteristic, and suggests that natural or inherited immunity from blackleg, which is so pronounced in young animals, gradually wears off with the approach to the fateful half-year mark. It seems to be very unusual for cattle in this country to contract the disease when past 9 years old. According to Swiss statistics (Hess), cows, when past 3 years old, are almost absolutely immune from blackleg.

CLASS OF CATTLE MOST SUSCEPTIBLE TO BLACKLEG.

As to the class of cattle most frequently affected by blackleg, the majority of reports agree that full-blood or high-grade stock are more subject to the disease than the common or low-grade range cattle.

In this country it is a noticeable fact that black'eg has been on the increase ever since the stock owners began to improve their cattle. A large number of ranchmen state that up to a few years ago their losses from blackleg were insignificant. When we consider the nature of the disease and the manner in which the infection takes place, we must admit that the more thin-skinned the animal, the more liable it is to become infected. It is generally conceded that the infection is almost always introduced into the system through abrasions of the skin in the form of minute punctures caused by thorns, spines, and grass burs (not through open wounds), and that to take effect the virus must penetrate into the subcutaneous tissue. Consequently, the thicker and tougher the skin of the animal the less liable it is to become infected.

On large ranches, where both ordinary and graded stock are kept, it is not difficult to observe that the majority of deaths from blackleg occur among the graded stock. The common-bred range cattle of Texas and the Western States are as hardy a race as ever existed. There is no reason to doubt that in regions where blackleg has prevailed for a number of years the native stock, through the "survival of the fittest," have acquired or inherited a partial or complete immunity from the disease. In a similar manner they have been enabled through constant exposure to resist an attack of Texas fever which would be fatal to other cattle.

RELATION OF SEX TO SUSCEPTIBILITY.

Whether there exists any predisposition to blackleg of one sex rather than the other is very doubtful. A number of the reports received state that steer calves are more frequently affected than heifers, but the great majority of stock owners are of the opinion that both sexes are equally susceptible. That this is correct so far as calves and yearlings are concerned is highly probable, as the sexual characteristics are but slightly pronounced in the young animals.

In older animals there seems to be a greater susceptibility to blackleg among the males. M. Hess, of Switzerland, has shown that among cattle over 3 years old the bulls and steers are more frequently atacked than the cows, but the limited number of cases of blackleg recorded in this country among cattle over 3 years old is not sufficient to warrant any conclusions.

DANGER IN HIGH FEEDING AND LACK OF EXERCISE.

As to the condition of the animals, by far the greater majority of cattle owners hold that it is the best cattle in the herd which principally become affected. Nevertheless, it is not uncommon for cattle in very ordinary or rather poor condition to contract blackleg. There seems, however, to be a greater susceptibility in young cattle which

are rapidly improving in flesh, as is the case when they are turned on fresh grass in the spring. On the other hand, the change from grass to hay in the fall does in many localities have an equally fatal effect on the stock. A cattle raiser in Nebraska states that "young cattle rapidly improving or declining in flesh seem to be most susceptible."

Another says that "poor cattle that pick up rapidly are more susceptible than those which remain in fairly good condition all the time." And still another says that "spring calves are mostly affected in the fall, when they are very fat and are changed from grass to hay, while yearling steers are affected in the spring when turned on grass." Other stock owners are inclined to attribute the appearance of blackleg to a lack of exercise, and claim that driving the herd for a considerable distance will temporarily check the disease. This theory, for several reasons, appears to be very plausible. In the spring, when the young stock suddenly find themselves in the midst of plenty, they need to feed over but a very limited area before they are filled up, when they lie down to ruminate. Under these circumstances, namely, plenty of food and little exercise, there is a tendency to an accumulation in the system of lactic acid, which has the property of greatly increasing the virulence of the blackleg bacillus. So great is the effect of lactic acid in this respect that a few drops added to a solution of blackleg vaccine will in the course of five to six hours restore to the highly attenuated spores their original virulence, and vaccine treated in this way will, if injected into a susceptible animal, produce a fatal attack of blackleg. As the lactic acid in the system is found principally in the muscles, and is excreted by them through their activity, there is every reason to believe that lack of exercise while the grass is fresh and abundant is a predisposing factor in the appearance of blackleg.

EFFECT OF SEASON, WEATHER, AND LOCATION.

As will be seen from the above, it is the spring and the fall which seem to be the seasons most favorable for the development of blackleg. The disease is, however, not confined to these seasons, but appears at all times of the year with more or less frequency. In the North, for instance in the Dakotas, the real blackleg season lasts from April to September or October, but outbreaks are reported in every month of the year. In Nebraska and Colorado the outbreaks are more evenly distributed over the whole year, with a slight increase during spring and fall, and the same may be said of Kansas, but with a slightly higher percentage of cases during fall and spring. In Oklahoma and the Panhandle of Texas it is difficult to single out any season as being more favorable to blackleg than others; but in central and

western Texas the greatest number of outbreaks occur during fall, winter, and spring, with but few cases during June, July, and August.

As to the effect of weather and location, we have already seen that blackleg occurs at all seasons of the year and in almost every country in the world; so it is not surprising that the answers received to questions sent out by this bureau have embraced every known climatic condition and every recognized geological formation, deposit, or stratum as either favorable or unfavorable to the development of blackleg. But most stock owners agree that when the disease has broken out there is nothing short of a hypodermic syringe and vaccine or the immediate removal of the affected herd to another pasture that will have any effect in checking the disease, and one of the two is generally resorted to in preference to awaiting the interference of frost or rain. Indeed, there is no climatic condition, however extremely opposite to the one prevailing, which will in anyway influence an outbreak of blackleg already in progress.

SYMPTOMS.

The symptoms of blackleg are so characteristic that the disease is easily recognized. The first symptoms may be either of a general or of a local nature, though more frequently of the latter. The general symptoms are high fever, loss of appetite, and suspension of rumination, followed by great depression. Respiration becomes accelerated; the animal moves around with difficulty, frequently lies down, and, when water is near at hand, drinks at short intervals and but a little at a time. The visible mucous membranes are at first dark red and congested, but they change in the course of 12 hours to a dirty leaden or purplish color.

The most important diagnostic feature is the development of a tumor or swelling under the skin. The swelling may appear on any part of the body and limbs, except below the knee or hock joint or on the tail. It is frequently seen on the thigh or shoulder, and, owing to the extensive discoloration of the swollen parts, as observed after the animal has been skinned, the disease has been popularly named "blackleg," or "black quarter." Tumors may also appear on the neck, the chest, the flank, or the rump. At first they are small and very painful. They increase rapidly in size and may in a few hours cover a large portion of the body. One or more of these tumors may form simultaneously, and when in close proximity to one another may become confluent. The neighboring lymph glands become considerably swollen.

If slight pressure is made on the tumor, a cracking sound is heard, and percussion gives a clear, resonant tone, due to the collection of gas in the affected tissue. The tumor is cool to the touch and painless in the center; the skin over it is dry and parchment-like. When the

tumor is lanced, a frothy dark-red fluid is discharged. If the incision is made while the animal is alive or immediately after death, there is no offensive odor to the discharge, although it smells like rancid butter, but decomposition takes place very soon after death. No pain is manifested when the center of the tumor is lanced, but as soon as the knife reaches the warm, inflamed part the animal will bellow loudly and flinch.

The swellings usually appear before the general symptoms, and they may even reach such an extent as to cause complete paralysis of the affected parts while the animal still looks bright and has a good appetite. This condition is, however, of short duration. As the swelling increases in size the general symptoms become more intense. The temperature may reach 107° F., while the respirations may exceed 140 per minute. The animal is unable to rise; the extremities become cold, and some time before death the temperature falls and may become subnormal. There is trembling of the muscles, which, as death approaches, may develop into violent convulsions.

With very few exceptions the disease terminates fatally, death generally occurring from 12 to 36 hours after the first appearance of the symptoms. A few cases linger from three to four days, and the disease may sometimes terminate in recovery (see p. 10).

APPEARANCE AFTER DEATH.

The carcass of an animal which has died from blackleg soon becomes very distended by gas, partially through fermentation in the intestines and partially through the formation of gas in the subcutaneous tissue, due to the presence of the blackleg bacillus. This distension, which is especially pronounced in the region of the blackleg tumors, extends for a considerable distance from the tumors and in the directions where it meets the least resistance—that is, where there is plenty of loose tissue. This is especially the case on the back and sides of the chest, on the shoulder and between the shoulder and chest, and on the external surface of the hind quarter. This tympanitic condition frequently causes the two legs on the upper side of the carcass to stand out straight without touching the ground.

A dark, blood-colored, frothy discharge flows from the nostrils and the anus. Decomposition takes place soon after death, except in the affected muscles, which retain their sweetish-sour odor without developing any putrid odor, even when the rest of the carcass has decomposed.

On the surface of the body may be seen one or more of the characteristic blackleg tumors. The skin covering these swellings is affected with dry gangrene. The connective tissue beneath the skin is infiltrated with blood and bloody serum and is distended with gas.

The distended muscles are dark brown or black, are easily torn, and the spaces surrounding them are filled with bloody liquid and gas. The muscle tissue is distended with numerous smaller or larger gas-filled cavities, often to such an extent as to produce a resemblance to lung tissue. Upon incision it does not collapse perceptibly, as the gas cavities are not connected with each other. The discoloration is deepest at the center, shading off toward the edges, and becomes brighter by contact with the air. On compression thick blood escapes, which is charged with gas, and has a disagreeable sour odor. The blood in the remaining parts of the carcass is normal and coagulates easily after death, forming a solid clot. The abdominal cavity sometimes contains a considerable quantity of bloody effusion. The mucous membrane of the intestine may be congested or inflamed, and the contents of the bowels may be covered with blood. The liver is congested, but the spleen is always normal.

DISEASES MISTAKEN FOR BLACKLEG.

Among the features of this disease, which distinguish it from anthrax, may be mentioned the unchanged spleen and the ready clotting of the blood. It should be remembered that in anthrax the spleen (milt) is very much enlarged, the blood tarry, coagulating feebly. The anthrax carbuncles and swellings differ from the blackleg swellings in not containing gas, in being hard and solid, and in causing death less rapidly.

It is difficult to distinguish between the swellings of blackleg and malignant edema, since they resemble each other very closely, and both are distended with gas. Malignant edema, however, generally starts from a wound of considerable size; it usually follows surgical operations, and does not result from the small abrasions and pricks to which animals are subjected in pastures. Inoculation experiments with guinea pigs, rabbits, and chickens will also disclose the differences in the above three diseases, since all of these species are killed by the germ of malignant edema, but only the first two species by the anthrax bacillus, while the guinea pig alone will succumb to the blackleg infection. Hemorrhagic septicemia may be differentiated from blackleg by its affecting cattle of all ages; by the location of the swelling usually about the region of the throat, neck, and dewlap; by the soft doughy character of these swellings without the presence of gas bubbles; and, finally, by the characteristic hemorrhages widely distributed throughout the body. Other means of diagnosis, which have reference to the specific bacilli, to the inoculable character of the virus upon small animals, and which are of decisive and final importance, can be utilized only by the trained bacteriologist and veterinarian.

MANNER OF INFECTION.

As already mentioned, the blackleg bacillus gains entrance into the body through abrasions of the skin, and perhaps in rare cases through the mucous membrane. In order to meet the requirements for the development of the spores—that is, an absolute absence of oxygen—it is necessary that the abrasion be minute in size and sufficiently deep to penetrate through the skin into the subcutaneous tissue; consequently incised or open wounds are not favorable to the development of blackleg, even if the infection is present in abundance. Slight wounds of the skin, such as those received from barbed-wire fences or from stubbles, thorns, spines, crossbars, and briers in the pasture, seem to be the most likely method of infection and correspond most closely to the only manner in which the disease may be produced artificially—that is, through hypodermic injection of the virus. It is doubtful whether the infection ever takes place through ingestion. In any case it has proved exceedingly difficult to produce the disease, even by feeding enormous doses of highly virulent material to susceptible animals.

The fact that in 99 per cent of all cases the tumors develop on the surface of the body seems also to indicate that the infection takes place through the skin, and the few cases recorded where the deeper-seated muscles have been affected—for instance, the muscles of the diaphragm, or those popularly known as the tenderloin—without the presence of tumors on the surface may be due to the germs gaining direct entrance into the lymph stream, which carries them directly to muscle groups located in the interior of the body. Several observers have found the blackleg organism in the mud of swampy pastures. By placing a little of this mud under the skin the disease has been produced.

TERMINATION AND TREATMENT.

As already stated, it is very rare that an animal affected with blackleg recovers. In Europe very few of the veterinarians and scientists who have made investigations along this line have ever been fortunate enough to observe a case of recovery.

In this country recoveries from blackleg do not seem to be extremely rare, if one may judge from the observations made and reported by the stock owners. Since anthrax does not prevail to any extent in most of the districts from which these recoveries have been reported,

it is highly probable that a large percentage of the cases referred to were really blackleg, as many of the stock owners describe the cases which came under their observation in such a manner as to leave very little doubt.

In reporting these cases of recovery a number of the cattlemen described the various therapeutic and surgical efforts to which they attributed the recoveries. An examination of the reports shows that the treatment generally adopted when the cattle are on the range consists in profuse bleeding and violent exercise in connection with deep incisions into the affected parts. In many cases an attempt is made to destroy the virus at the point of infection by pouring turpentine, various acids, concentrated lye, petroleum, vinegar, etc., into the incisions. The bleeding is done by opening the jugular vein, cutting off the tail, or "nerving" between the hoofs, which generally means to make an incision between the hoofs, severing the artery which is located there. The violent exercise consists in tying the affected animal to the saddle horn and dragging it for one or more miles.

The condition in which this treatment leaves the unfortunate sufferer is, however, in most cases, deplorable. When the disease has developed to a point where it is safe to conclude that an experienced stockman can not well mistake it—that is, when a crackling tumor has appeared and the animal is lame—the only way to recovery is either through absorption of the exudate, before the affected muscles have been destroyed and the covering skin becomes gangrenous, or else the affected tissues must slough away and be replaced by scar tissue. In all cases where the recovery is reported to have taken place in the course of a few days or a week, the first way is the only possible one in which it could occur. But here we must accept the owners' diagnoses with reservation, as no authentic cases are recorded in this country.

If the animal survives the first five to seven days, it seems that the disease has exhausted itself, and if the depleted system has strength enough left it enters upon a long convalescence, constantly retarded by the extensive local tissue destruction, which must heal through granulation under a constant drain upon the system from suppuration, and which in most cases leaves the animal a cripple or a runt for life. And when it is remembered that the majority of stock owners who have recorded one or more cases of recovery as a result of certain treatment have applied the same treatment and remedies in dozens of other cases without success, it seems to be in every respect wiser and more humane either to leave the affected animal alone or dispatch it as quickly as possible; for there can be no doubt that chasing an ani-

mal affected with blackleg over miles of ground, with virulent blood oozing at every step from a number of incisions in the swollen parts, is sure to scatter the infection in a manner which could never occur under natural circumstances, and is bound to bring to grief many a succeeding generation of calves. For this reason it is strongly advocated never to use the knife on an animal suffering from blackleg unless it is kept confined in a place which can afterwards be disinfected thoroughly or from which healthy animals are constantly excluded; and it should be borne in mind that the spores of the blackleg bacillus retain their disease-producing properties for years after they have left the body of the affected animals, and that, although they do not multiply outside of the animal economy, they are merely awaiting an opportunity to regain an entrance thereto and continue their destructive work.

PREVENTIVE MEASURES.

From the preceding discussion it will be seen that remedial treatment is of little avail, and consequently our principal recourse against the disease is prevention.

The various measures employed for this purpose may be classified in two groups: (1) Those which aim at destroying or preventing the spread of infection in all places where cattle are kept, and which may be termed *hygienic* measures; and (2) those which operate to fortify the systems of susceptible animals against an effective invasion of the blackleg germ, and which may be called *prophylactic* measures.

HYGIENIC MEASURES.

How infection is spread.—When it is known that blackleg occurs with more or less regularity in a pasture, feed lot, or stable, it is due to the presence of the blackleg germ, either in the ground of these places or in materials (coarse feed, etc.) brought there regularly. Whenever an animal becomes affected, the germs multiply by the million in its system, and their liberation, through natural or artificial means, tends to preserve, increase, or spread the infection. In the large pastures of the West and Southwest an affected animal is rarely noticed until after death. It is then frequently too late to attempt to prevent the spread of infection, for wolves and other vermin usually attack the carcass in short order, without even waiting for the animal to die, and only the bones and pieces of the hide are found scattered over an acre or more of ground.

In more densely populated districts, where a sick animal is readily discovered, there is, as mentioned earlier in this article, often an inclination to "doctor" an animal, usually by means of a jackknife,

and the result is the same as in the other case—the infection is scattered broadcast from incisions made in the affected part.

In some districts the cattle that die from blackleg are skinned in order at least to save the hide, and the remaining parts of the carcass are left to take care of themselves. This process naturally assists in scattering the infection. *It is therefore of the utmost importance that cattle owners in the infected districts be made to realize that an animal affected with blackleg may be the cause of large subsequent losses from the same disease, perhaps not immediately, but within a period of years to follow; and it can not be too urgently recommended that they make every effort to reduce the danger by taking adequate measures to destroy as completely as possible this source of renewed infection.*

Destruction of infection.—For this purpose the French scientists recommend various methods, some of which, however, are impracticable under the conditions which obtain in the infected districts of this country. They propose, for instance, to place the dead animals in a tank of sulphuric acid until completely dissolved. Where wood is plentiful the best method is to cremate the carcass. In order to insure its complete destruction, the dead animal should be placed on a couple of logs and plenty of dry wood heaped around it. A couple of quarts of kerosene oil should then be poured on and fire set to it. It is necessary that the carcass be entirely destroyed; if any part of it remains, another fire should be built over it.

In a pasture where wood is scarce the carcass may be buried. This method is always more or less unsatisfactory, as the infection is not destroyed, but merely removed to a few feet below the surface, whence it may return through various means of egress—for instance, as demonstrated by Pasteur, through the agency of earthworms. It is therefore of importance that the hole in the ground be made at least 6 feet deep and the carcass well covered with quicklime before the earth is filled in. The lime has no special germicidal effect on the blackleg bacillus, but may prevent the infection from being carried to the surface. The place where the animal was lying before being buried, as well as the top of the grave, should be freely sprinkled with a 2 per cent solution of creolin, or any of the carbolic sheep dips or disinfectants which are guaranteed to contain thymol or eucalyptol. The two latter substances are specially recommended by the French scientists because of their destructive action on the blackleg germs. Owing to the difficulty of destroying the infection, it may be well to repeat here that all attempts at treating an animal affected with blackleg through scarifications or incisions into the affected part should be abandoned as dangerous and unprofitable. It is far better to destroy the animal as soon as all doubt as to the

diagnosis has been dispelled, and to burn the carcass immediately, without removing it from the place where found. As stated before, the fresh virus is much more easily destroyed than the dried, and by quick action a better result is always assured. If the animal dies from blackleg in a stable, it becomes necessary to remove the carcass to a proper place for its cremation or burial. Care should be taken to scatter straw or hay wherever there is a possibility of infecting the stable floor or the ground with the discharges or exudations from the carcass while it is being removed. All litter should be removed from the stable and burned, together with that used in removing the carcass. The woodwork and floors of the stable should be thoroughly and repeatedly soaked with one of the above-mentioned disinfectants or with corrosive sublimate (1–1,000).

Freeing pastures of infection.—The question of how completely to eradicate the disease from a pasture has been much discussed, but no sure means have been found. The usual method of preventing the infection from renewing itself by keeping cattle away from the pasture until it has died out can not be employed in this case, as outbreaks have been recorded in this country in pastures where no case of blackleg had occurred for 11 years, and few people can afford to keep a pasture unstocked for that length of time. It has been claimed that complete drainage and cultivation of the soil for several years will prevent further outbreaks, but where the question concerns large pastures which are unfit for anything but cattle raising this measure is, of course, out of consideration.

Several ranch owners, especially in Texas, have reported that blackleg never caused losses of any consequence until after it became impossible to burn the pastures off regularly every winter, and this statement, which in some cases is based upon actual observation, is no doubt correct. Whether this condition is due to overstocking or to an actual decrease in the annual rainfall need not be discussed here, but the fact remains that in many of the southwestern cattle-raising districts the winter grass, as a rule, is barely sufficient to keep the stock alive until spring, and not a straw remains to be burned off at the end of the winter. As stated before, no agent has a more destructive effect on the blackleg germs than heat, and no doubt it might be profitable for owners of badly infected pastures to allow the grass in them to grow rank and burn it off during the winter. It is held by the French scientists that when the infection on the surface becomes attenuated through exposure to varying climatic conditions it may have its virulence reenforced through lactic acid formed during the natural fermentation in the soil. Such an acidity of the soil would, however, immediately be neutralized by burning off the pastures, thereby depositing on the surface a layer of alkalies in the form of ashes, and the

attenuation of the germs which escaped destruction through the heat might continue without interruption.

Removal of cattle to new pastures.—When blackleg appears in a herd, a common remedy is to move the well animals immediately to another pasture. From a number of reports received this seems in certain regions to be considered the only sure means of stopping the disease, but in most cases the effect is but temporary. If the new pasture to which the animals are taken is free from infection, it is natural that no more cases should occur, if none of the animals were infected previous to leaving the old pasture. Such cases would develop in the course of a few days, and if no precautions are taken infect the new pasture to a greater or less extent. But, as a rule, conditions are very much alike in all pastures on the same ranch or farm, and after a while, when the animals have become familiar with their new surroundings and begun to thrive again, the disease reappears. The results, however, seem better when the pasture to which the afflicted cattle are taken is of decidedly poorer quality than the one where the disease first broke out. This, in connection with the fact that the change, which generally gives the cattle more or less exercise in rounding up and driving, produces a temporary lull in the outbreak, seems to indicate that the animals under certain conditions are less susceptible to the disease, and that the temporary increase in power of resistance must be due to certain chemical or metabolic processes in the animal economy which are dependent upon the relative proportion between the amount of exercise and the amount of nutrition of which the animal partakes. All cattle owners in the infected districts agree that a reduction in flesh, no matter in what condition the animals may be, tends to allay or stop an outbreak of blackleg. But as it is contrary to the interests of stock raisers to interfere in any way with the growth and development of the young cattle, it is obvious that preventive measures along this line should be avoided or resorted to only as a temporary relief, while less injurious and more certain remedies are provided in the meantime.

PROPHYLACTIC MEASURES.

Setoning, or roweling.—Setoning, or roweling, which consists in producing a large running sore in the dewlap or on the shoulder, and which, through profuse suppuration, drains the vitality of the animal, should only be resorted to as a temporary measure. When practiced regularly it simply prevents growth and stunts young animals, besides affording an opportunity for the introduction of other disease germs. In England, where public opinion is against vaccination, this method has been employed extensively, and much has been written for and against it. The two principal authors on

this question, Stewart Stockman and J. McFadyean, are both of the opinion that roweling is of no value as a preventive measure, the former even holding that it has the opposite effect. In support of this statement he quotes the following case:

> At the request of a client whose losses from black quarter are annually very high, a friend of mine setoned 15 yearlings. For some reason a sixteenth animal was not setoned. The 16 animals were all pastured on the same meadows. All the setoned animals died of black quarter and were survived by the one that had not been setoned.

Such evidence speaks for itself. The same author has proved experimentally that animals which have been setoned for one month succumb more readily to an inoculation of blackleg virus than animals which have not been setoned at all, and a number of stockmen in this country who have been in the habit of roweling their cattle declare that the protective effect of the seton soon wears off, although it seems effective for a while. The seton, if used at all, should not be left in the sore for more than a week or 10 days, or sufficiently long to allow the owner to obtain blackleg vaccine and use it on his cattle.

Preventive vaccination.—To Arloing, Cornevin, and Thomas belongs the honor of first discovering that animals may be protected against blackleg by inoculation with more or less virulent material obtained from animals which have died from blackleg. They found that the hypodermic injection of minimal doses of fluid from a blackleg tumor did not necessarily result in death, but frequently produced a mild attack of the disease, unaccompanied by any swelling, and that animals treated in that way were afterwards possessed of a very high degree of resistance to the disease. There are, however, few diseases where the individual susceptibility varies to a greater extent than is the case in blackleg, and, as it was impossible to ascertain beforehand the degree of susceptibility or power of resistance possessed by each animal, the exact dose to employ in each case could not be determined, and the method was abandoned as being too dangerous. Even when the inoculation was made at the extremity of the tail, it frequently resulted in the development of a swelling which spread to the rump and killed the animal, or else the tail became gangrenous and dropped off.

When the virus, either fresh from a tumor or dried, is introduced into the blood stream or into the trachea, the animal shows great resistance to its effect and subsequently becomes immunized. It is, however, rather difficult to inject the virus either into the jugular vein or into the trachea without infecting the surrounding connective tissue, and the technique of the operation is too complicated to be of practical value when large numbers of cattle are to be vaccinated. Nevertheless, the French scientists practiced it on five hundred animals, with only one death resulting from the operation.

Attenuated virus.—Prolonged exposure to a high temperature serves to attenuate the virulence of either fresh or dried virus. This fact was employed by the above-mentioned authors for the preparation of a vaccine which may be used in everyday practice with little danger of injuring the cattle. The material used for the vaccine is obtained from a fresh blackleg tumor, by pounding the muscle tissue in a mortar with the addition of a little water and squeezing the pulp through a piece of linen cloth. The juice is spread in layers on plates and dried quickly at a temperature of about 35° C. This temperature does not in the least affect the germs, and the dried virus obtained in this way retains a high degree of virulence for two years or more.

When vaccine is to be prepared, the dry material is pulverized and mixed in a mortar with two parts of water until it forms a semifluid homogeneous mass. This is spread in a thin layer on a saucer or glass dish, and placed in an oven, the temperature of which can be regulated with exactness. The reason for mixing the virus with water is to insure a quicker and more uniform attenuation. The temperature of the oven is previously brought up to 100° to 104° C., and the virus is allowed to remain in it for seven hours. When removed, it appears as a brownish scale, which is easily detached from the dish. The scale is pulverized and mixed with water, and when inoculated under the skin of calves in doses of 1 centigram per head it produces partial immunity. Subsequent inoculation with virus which has been heated for the same length of time, but at a temperature of 90° to 94° C., serves to reenforce the immunity. The inoculation is followed by insignificant symptoms. In a few cases there is a slight rise in temperature, and by close observation a minute swelling may sometimes be noted at the point of inoculation. Eight to ten days are allowed to pass between the first and the second inoculation. For reasons already explained, the vaccine is injected at a place where the subcutaneous connective tissue is dense and unelastic, generally at the extremity of the tail or the external surface of the ear, as far from the base of either organ as possible. The immunity conferred in this way lasts for at least 18 months, but animals which are vaccinated before they are 1 year old should be revaccinated the following year.

Early inoculation methods.—The method of vaccination for blackleg, popularly known as "the French method," "Arloing's method," or the "Lyons method,"[a] was first introduced in 1883 and was generally adopted during the following two years. Several thousand cattle were vaccinated in France, Switzerland, and Germany, and the results were highly satisfactory. The operation, however, is quite difficult on account of the great density of the subcutaneous tissue of the tail, which makes it difficult to insert the needle; in fact, it is

[a] The laboratories of Arloing, Cornevin, and Thomas are located at Lyon, France.

necessary first to punch a hole with a strong trocar and loosen the skin sufficiently to form a sac or pocket large enough to receive the vaccine. Afterwards a ligature is tied around the tail to prevent the vaccine from escaping through the hole, and this ligature must be removed a short time after, so as not to interfere with the circulation. When the inoculation is made too close to one of the joints the needle is liable to wound the cartilaginous disks and cause the formation of an abscess, which may result in necrosis and the dropping off of the tail. In any case, the operation has to be performed by an expert, besides requiring considerable time. Consequently, when large numbers of cattle were to be vaccinated the method was both expensive and inconvenient, and when a modification was suggested it was eagerly accepted. In 1888 Professor Kitt, of the veterinary college in Munich, Bavaria, took up the question, and, after experimenting with Arloing's vaccine on a number of animals, came to the conclusion that the second vaccine may be injected alone without any danger to the animal, and that such a single vaccination confers immunity from subsequent attacks of the disease. He further modified Arloing's method by making the injections in the shoulder region, where the skin is loose and easily pierced by the needle.

The Bureau vaccine.—Experiments were begun in the Pathological Laboratory of the Bureau of Animal Industry in the fall of 1896 for the purpose of preparing a blackleg vaccine which by a single inoculation would produce practical immunity and still be sufficiently attenuated to cause only a minimum amount of loss at the time of inoculation. All the various methods already mentioned were tried, and it was finally decided to adopt Arloing's principle, with Kitt's modifications. The vaccine produced gave, as far as could be ascertained by numerous inoculations, such uniformly good results that it was decided to place a limited number of doses in the hands of reliable stockmen in order to have them test it in practice on their cattle.

The districts in which blackleg especially prevails are the vast plains and cattle ranges of the West and Southwest, where the nearest veterinarian is often a hundred miles away; stock owners in these regions would either have to vaccinate their own cattle or else do without it. However, they accepted the proposition, and the many hundred thousands of successful vaccinations performed by the ranch owners or their employees tend to prove that the preventive inoculation for blackleg may be carried out satisfactorily by any ordinarily intelligent person who will make himself thoroughly familiar with the printed directions before he attempts to administer the vaccine. In the more densely populated districts the farmers in many cases have engaged a veterinarian to prepare and inject the vaccine, but the general rule has been for the stock owners to do it themselves, and the testimonials received are all to the effect that the printed directions are plain and that no difficulties are experienced in following them.

DISTRIBUTION OF THE VACCINE, AND ITS RESULTS.

The effect of the vaccine prepared by this bureau in preventing outbreaks of the disease and in immediately abating outbreaks already in progress has been highly satisfactory, and it is not to be doubted that thousands of young cattle have been saved to the stock owners during the eighteen years in which the vaccine has been distributed. More than 23,859,873 doses have been sent out during this period, and from reports received it is safe to conclude that at least 20,000,000 animals have actually been vaccinated, whereby the percentage of loss from blackleg has been reduced to less than one-half of 1 per cent. When it is considered that in regions where blackleg prevails the losses from this disease alone exceed those from all other causes combined, and in certain badly infected regions amount to more than 10 per cent of the annual calf crop, then it is plain that the general introduction of preventive vaccination must be of material benefit to the cattle raisers in the infected districts.

With these figures before us there is every reason to believe that, with the continued use of blackleg vaccine in all districts where the disease is known to occur, and an earnest effort on the part of the stock owners to prevent the reinfection of their pastures by following the directions given by this bureau, blackleg may be kept in check and gradually eradicated.

The danger of infection must naturally diminish in proportion to the decrease in the amount of virulent material deposited upon the pastures. With a mortality after vaccination of less than one-half of 1 per cent, it is obvious that this preventive measure serves a double purpose in combating the disease. It is, therefore, to the interest of every stock owner who vaccinates his cattle to induce his neighbors to take the same precaution, especially in districts where it is difficult to find the animals dead of the disease and dispose of them before they are attacked by vermin.

THE WORK TO BE CONTINUED.

The distribution of blackleg vaccine will be continued by this bureau until further notice, and adequate measures have been taken to avoid all delay in sending the vaccine immediately on receipt of the application. It is advisable that all stock owners in infected districts should vaccinate their young stock regularly, without awaiting an outbreak of the disease, as heavy losses may be sustained in the course of a few days.

For the benefit of those who have not yet obtained vaccine from this bureau, the following directions are given:

HOW TO APPLY FOR BLACKLEG VACCINE.

A regular application blank will be mailed to any stock owner who so requests, although a letter stating the number of animals to be vaccinated will be treated as an application.

A number of stock owners have obtained vaccine in excess of what they actually needed, simply to have it on hand in case they should want to use it. This practice has caused unnecessary work for this bureau, and, on the other hand, stock owners whose cattle were actually dying from blackleg had to wait on this account from two to three weeks or even longer before they could be supplied.

It has therefore become necessary to require each stock owner who wishes to obtain vaccine from this bureau to certify on his honor that the number of doses of blackleg vaccine applied for by him are actually needed at the time the application is made, and that they will be used within four weeks after receipt, on his own cattle, or on cattle in which he is actually interested, or of which he is actually in charge.

Attention is called to the rule that under no circumstances will blackleg vaccine be sent to any one person for distribution to others, except in the case of designated State officials or sanitary officers. Each stock owner should apply directly to this office for the amount of vaccine required for his own cattle, and this will in each case be sent to him direct.

All applications for blackleg vaccine should be addressed as follows:

Chief of the Bureau of Animal Industry,
U. S. Department of Agriculture,
Washington, D. C.

In order to obtain reliable statistics regarding the effect of the Government vaccine, it is necessary that this bureau be informed of any deaths from blackleg subsequent to vaccination.

Neither *vaccine* nor *application blanks* will in any case be furnished to any one person for distribution among others except as specified above. *Veterinarians* who wish to obtain vaccine for their clients may forward the names and addresses of those who wish their cattle vaccinated, and an application blank will be forwarded to them. This must be filled out and certified to by the cattle owner himself, and the vaccine will be sent to him direct.

VACCINATING OUTFIT.[a]

To prepare the vaccine in such a way that it may be injected hypodermically, it is necessary to obtain certain implements which, together with the hypodermic syringe, are known as a vaccinating outfit. This consists of a porcelain mortar with pestle, a small glass fun-

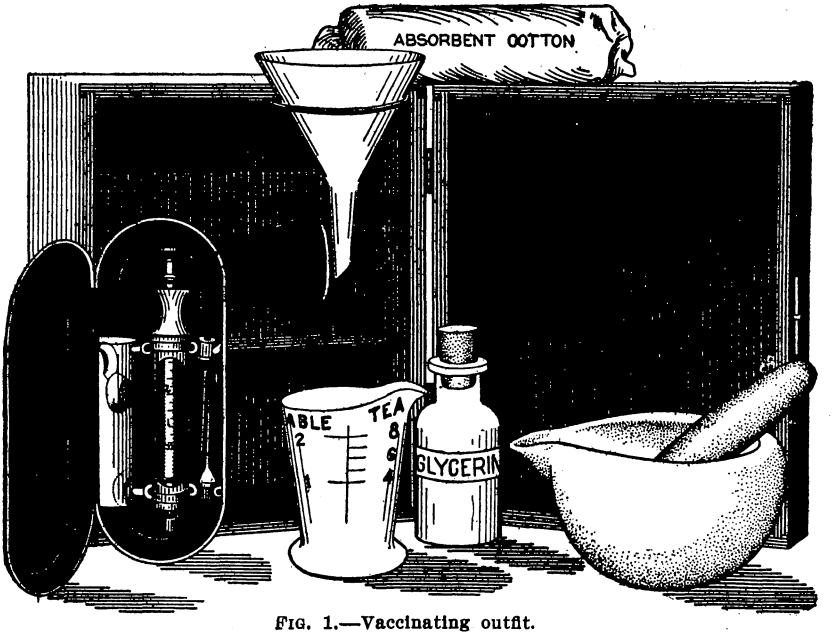

FIG. 1.—Vaccinating outfit.

nel, and a measuring glass. Figure 1 is an illustration of the vaccinating outfit recommended by this bureau. All of the utensils, including the hypodermic syringe and a package of absorbent cotton, are fitted in a strong, polished oak box, which, by means of an adjustable wire loop, serves also as a support for the funnel when the vac-

[a] A complete vaccinating outfit, including hypodermic syringe, can be obtained from Z. D. Gilman, 627 Pennsylvania avenue NW., Washington, D. C., for the sum of $5, postage prepaid. The outfit is prepared by the firm named in accordance with the plans of this bureau. Similar outfits will no doubt be for sale by other dealers furnishing this class of supplies, but until this may be the case the unusual course of mentioning a dealer by name in a Department publication is followed.

cine is filtering. The syringe, two hypodermic needles, and an extra glass barrel are packed in a separate metal box which is inclosed in the oak box.

ANSWERS TO NUMEROUS INQUIRIES.

In order to avoid unnecessary correspondence the following salient points concerning the use of blackleg vaccine are presented below in a concise manner for emphasis.

1. Owing to the fact that a number of cattle owners have attempted to modify or have otherwise deviated from the printed directions, losses have occurred which might have been easily avoided. It is therefore urgently recommended to follow the directions implicitly, and especially to *refrain from castrating, spaying, and dehorning at the time of vaccination.*

2. *Vaccine which for any reason is not used should be returned to this office immediately.*

3. *All vaccine should be used within twelve months from the date on the back of each package.* After this period has elapsed the vaccine may be used to advantage, in cases of emergency, as a first vaccine, but to insure immunity it is advisable to revaccinate with fresh vaccine in the course of two weeks.

4. *The only vaccine distributed by this Department is a single powdered vaccine* for the prevention of blackleg, and it may be injected at any season of the year.

5. *Blackleg vaccine is distributed free of charge* to stock owners of the United States.

6. Neither vaccine nor application blanks will be furnished to any person for distribution among others; *each stock owner must apply in his own behalf.*

7. The immunizing properties of the vaccine are not usually imparted until 10 or 12 days following the vaccination.

8. Deaths of animals within one or two days after vaccination should not be attributed to the vaccine, but to the fact that they were already infected with the disease before vaccination.

9. It is not advisable to vaccinate an animal after the symptoms of blackleg have developed, as *the vaccine is a preventive and not a curative agent.*

10. Vaccination is generally followed by insignificant symptoms. In some cases there is a slight rise in temperature, and a minute swelling may sometimes be noted at the point of injection.

11. Calves vaccinated before they are six months old lose the artificial immunity produced, and *should be revaccinated before the beginning of the next blackleg season.*

12. Animals which have been vaccinated may be revaccinated after an interval of two weeks without any unfavorable results.

13. It is not advisable to vaccinate pregnant heifers within one month of the time for them to calve.

14. Immunity is not transmitted by the immunized parent to the offspring.

15. Do not vaccinate cattle while they are overheated.

16. Animals should be *vaccinated on the side of the neck just in front of the shoulder and always on the same side.*

17. The only satisfactory method of administering the vaccine distributed by the Department is by the use of *a hypodermic syringe.* The method of soaking a cord in our vaccine solution and inserting a portion of the cord under the skin can not be recommended.

18. Anthrax is an entirely different disease from blackleg, and therefore *blackleg vaccine does not act as a preventive against anthrax.* Anthrax vaccine is not distributed by the Department.

Approved:

D. F. HOUSTON,

Secretary of Agriculture.

[Cir. 31.]

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